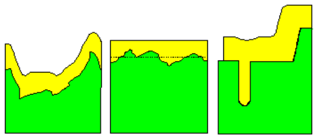
3.2.4 Summary to: 3.2 Mechanical Properties

- Thin films have other spatial properties besides their thickness, i.e. roughness
  - Interface roughness and surface roughness ***R*** defined by their "root mean square".



$$R = \left(\frac{1}{N}\sum_{i=1}^{N} z_i^2\right)^{1/2}$$

- Useable thin films adhere to their substrate.
  - A direct measure of adhesion is the interfacial energy γ_{AB} between film **A** and substrate **B**.
  - The phase diagram provides some guideline. Complete miscibility = good adhesion, (eutectic)) decomposition =(?) low adhesion. Calculations of γ are difficult.
  - Full adhesion can only be obtained for films *grown* on a substrate. Adhesion energies can be measured.

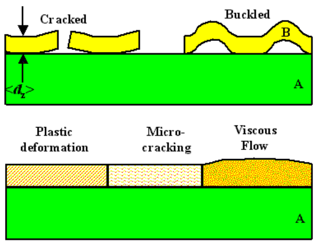
- Generally, there will be stress σ and strain ϵ in a thin film and its substrate.
  - A major source of strain is the difference of the thermal expansion coefficients α

Stress and strain in thin films can be large and problematic!

$$\epsilon_{TF} = \Delta T \cdot \Delta\alpha$$

$$\sigma_{TF} = Y \cdot \Delta T \cdot \Delta\alpha$$

- Stress in thin films may relax by many mechanisms; and this might be good or bad:
  - Cracking or buckling
  - Plastic deformation
  - Viscous flow
  - Diffusion
  - Bending of the whole system (Warpage)
  - Warpage can be a serious problem in semiconductor technology.



Exercise 3.2-1

All Questions to 3.2